lieved these symptoms momentarily by reducing the pressure of the cerebrospinal fluid. Antitoxin was employed in 5 cases, and the antistreptococcus serum in another without any apparent benefit. The best sedative seemed to be opium in some form. The use of chloral, bromides, ergot, and potassium iodide yielded no satisfactory results. Resort was had to surgery in 1 case, in which two lateral flaps were made in the cranium, hoping by this method to establish free drainage, but the patient died two days later.

In conclusion, we desire to thank the visiting physicians to the Hartford Hospital, as well as their assistants, for their hearty co-operation. We are also indebted to Dr. E. A. Wells, then assistant visiting pathologist and bacteriologist, for much assistance; and finally, and not the least, we are under obligations of the hospital internes for many acts of service.

TUMORS OF THE CAUDA EQUINA AND LOWER VERTEBRÆ.

A REPORT OF NINE CASES: SEVEN WITH NECROPSY, THREE WITH OPERATION.[1]

By William G. Spiller, M.D.,

PROFESSOR OF NEUROPATHOLOGY AND ASSOCIATE PROFESSOR OF NEUROLOGY IN THE UNIVERSITY OF PENNSYLVANIA; NEUROLOGIST TO THE PHILADELPHIA GENERAL HOSPITAL.

(From the Department of Neurology and the Laboratory of Neuropathology of the University of Pennsylvania.)

The symptoms of tumor of the cauda equina resemble closely those produced by certain other conditions. The diagnosis must be made between hysteria, multiple neuritis confined to the lower limbs, intrapelvic tumor, tumor or caries of the lumbar vertebræ or sacrum, lesions within the vertebral canal but external to the dura, tumor or other lesion (hemorrhage) of the conus, and tumor of the cauda equina.

Hysteria. One of the most important symptoms of tumor of the cauda equina is pain in the lower limbs, severe in type, usually appearing first in one limb and later in the other, and more commonly simulating sciatica. Pain in the lower limbs may be distinctly hysterical. I have recently observed two cases of this character in which organic lesions as causes of the pain probably did not exist. A differential diagnosis usually is possible after careful study, but in certain cases it may be very difficult. In addition to the pain, weakness of the lower limbs may occur in hysteria.

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[1] Read at the meeting of the American Neurological Association, May 7, 8, and 9, 1907.

MULTIPLE NEURITIS OF THE LOWER LIMBS. Neuritis is very seldom confined to both sciatic nerves and their branches, although it may be limited to the lower limbs, and I cannot agree with Müller[2] when he says that the upper limbs are almost invariably (fast regelmässig) implicated. I have seen neuritis confined to the lower limbs, but it is undoubtedly uncommon. Such neuritis does not usually cause great difficulty in diagnosis. The history of alcoholism or preceding infectious disease, or even when these factors are absent, the intense pain on pressure over the nerves and muscles, especially those of the calves, is very diagnostic, and there may be impairment of objective sensation and of motion; but pain on pressure over the limbs may occur in tumor of the cauda equina. The peroneal nerve supply is most likely to be affected in neuritis, but we recognize fully that isolated peroneal palsy occasionally occurs from intrapelvic lesions, and it is believed by some that the fibers forming the peroneal nerves are distinct from the other fibers in the sciatic nerve to their origin in the plexus of nerves in the pelvic cavity, and that they are more exposed to trauma within the pelvis than are the other fibers of the sciatic nerves. Bilateral peroneal palsy may occur from a lesion within the dura confined to the fifth lumbar and first sacral roots.

Bilateral sciatica is usually indicative of tumor. No diagnosis should be made with more caution than this of bilateral sciatica, and the condition is far too frequently regarded as merely ordinary sciatica in each limb. The prognosis should always be given with great reserve. Tumor of the pelvis, vertebræ, or cauda equina is often diagnosticated as sciatica which at first may be unilateral and later bilateral, and the condition in its commencement is the same as that of sciatica without disturbance of objective sensation and without motor paralysis.

Sciatica or multiple neuritis, even when the latter is in the lower limbs, is not usually associated with paralysis of the bladder and rectum, but the statement of Müller,[3] that this paralysis "noch nie beobachtet ist," is surely too strong. I should modify it by saying that it is very uncommon. I have seen multiple neuritis with implication of the bladder, and have a case under my care at present.

While tenderness of the muscles is usually indicative of peripheral neuritis, it has been observed in cases of tumor of the vertebræ and cauda equina, also in my cases II, IV, and V, and in the case reported by Sailer. In Schmoll's case of tumor of the cauda equina both sciatic nerves were exceedingly tender to touch. The condition is like the pain of meningitis. The posterior roots are greatly irritated, and any moderate peripheral stimulation is transmitted with unusual intensity. At least, this seems to me a reasonable explanation of the hyperesthesia of meningitis, and I do not regard the diagnosis of a complicating neuritis as necessary. We can hardly assume that peripheral neuritis occurs in every severe case of meningitis, as we must do if we attribute the pain of meningitis to neuritis, as hyperesthesia is so common in meningitis.

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[2] Deutsche Zeitschrift für Nervenheilkunde, 1899, xiv, 1.

[3] Loc. cit.

Neuritis of the lower limbs is often confined to the territory of certain nerves, although it may be general.

The diagnosis between neuritis confined to the lower limbs and tumor of the cauda equina may, in the early stages of the disease, be exceedingly difficult.

INTRAPELVIC TUMOR. A tumor of the pelvis may cause symptoms much like those of lesions of the cauda equina. The nerves forming the plexuses are more spread out in the pelvis than are the roots of the cauda equina, consequently an intrapelvic tumor may cause only unilateral symptoms, or at least symptoms confined to one side a long time, or preponderatingly unilateral, but the symptoms may be bilateral from the beginning if the tumor is medianly situated, or is multiple, or if the lesion is fracture. There may be the same pain and weakness either from tumor in the pelvis or in the cauda equina. Examination by the rectum or vagina is often useless in the early stages of intrapelvic tumor, as the new growth may be higher than the finger can reach, or may be too small or too flat to be detected. Later, when it has attained considerable size, it may be more easily palpated by the examining finger.

In a case seen by me in consultation with Dr. David Riesman, bilateral sciatica was for a long time the only symptom of intrapelvic tumor, and rectal examination was at first of no assistance in the diagnosis; later, the tumor grew to a large size and the diagnosis became easy.

The tenderness over the spine on pressure is not so likely to be present in intrapelvic tumor, but this tenderness has seemed to me rather an unreliable sign.

The motor and sensory symptoms usually occur more closely together in point of time in intrapelvic lesions than in caudal lesions, as in the pelvis both motor and sensory fibers are combined in the nerves, whereas in caudal lesions they are separate.

In pelvic lesions we expect symptoms indicative of implication of groups of fibers belonging to the lumbar and sacral plexuses, and not of one single nerve; still, we know that the peroneal nerve alone may be implicated in intrapelvic lesions. This is more likely to occur from trauma than from tumor.

In all the groups of cases under consideration the paralysis is flaccid, reaction of degeneration may be present, later atrophy may develop, and the tendon reflexes are diminished or lost, although it is possible to have some exaggeration of certain tendon reflexes when the nerves concerned in these reflexes are not implicated, and the neuritis is confined to other nerves even of the same limbs; or, in the early stage of neuritis, when the condition is one of irritation rather than degeneration.

In all these groups of cases the lesions implicate the peripheral segments (peripheral neurons), either the nerve fibers or nerve cells. When the lesion is above the lumbar region the clinical picture is a very different one.

The anesthesia of lesions below the cord proper (in the cauda equina, vertebræ, or pelvis) is not likely to be dissociated, as it may be in lesions within the spinal cord, but occasionally it is.

In plexus lesions, when the bladder and rectum are paralyzed, the power of erection and ejaculation is likewise usually impaired or lost, and yet a case of pelvic tumor reported by Müller[4] shows how difficult the diagnosis as regards these symptoms may be.

The pain was confined to the right lower limb one year. Three-quarters of a year after the beginning of the pain paralysis of the bladder and rectum appeared, and after the first year pain was felt in the left lower limb. The occurrence of vesical and rectal symptoms three-quarters of a year after the pain began Müller regards as contrary to the diagnosis of intravertebral lesion,and yet in one of my cases (Case II) of cauda equina tumor there can be little doubt that had the patient lived paralysis of the bladder and rectum would have occurred, even though it would have been months after the symptoms began. Much experience, Müller says, shows us that in lesions of the lower part of the vertebræ causing diminution of space the vesical and rectal nerves are first affected. This Case II of my series shows plainly that this statement is not always correct. Fibrillary tremors were present in Müller's case of intrapelvic tumor, and these are uncommon when the nerve cells are not involved. Although the bladder and rectum were paralyzed, erection was preserved, but ejaculation of semen was disturbed by paralysis of the ischiocavernosus and bulbocavernosus muscles. The fibers for erection, therefore, seem to rise higher in the cord and to leave the cord at a different level from those of the bladder and rectum, but the dissociation of these symptoms is certainly uncommon in lesions of the plexus. It is well to remember that it may occur, as demonstrated by this important case of Müller's.

Extremely interesting is a fact brought out by Müller, that the sensation of the lateral part of the scrotum is not from the coccygeal plexus, as is that of the median portion, but, like that of the testicles, is from the lumbar portion of the cord. Very little attention has been paid to this difference in origin of the fibers providing sensation to the lateral and median portions of the scrotum, but I have been able to confirm the correctness of the observation repeatedly.

TUMOR OF THE VERTEBRÆ. Here, as in all the tumors under consideration, pain is a very prominent symptom, and is likely to become bilateral sooner than in intrapelvic tumor. The posterior roots are caught in their passage through the intervertebral foramina, and the pain is usually constant, with exacerbations. Pressure over the lower vertebræ and sacrum may be exceedingly painful. It is impossible, in my experience, to decide from the symptoms whether the tumor is confined to the vertebræ or whether it extends also over the anterior surface of the dura. Of differential value in diagnosis from tumor of the cauda equina is the fact that the symptoms are likely at first to be confined to the distribution of a few nerve roots when the tumor begins in a vertebra, but that this is not always a reliable sign is shown by my Case II, in which the tumor was confined to the cauda equina, therefore was within the dura, and yet the symptoms indicated implication of only a few nerve roots. It is desirable to find some reliable means of clinical differentiation between tumor confined to the vertebræ and tumor on the dura or inside the dura without implication of the vertebræ. The former condition makes a radical operation impossible, although it does not forbid the attempt to cut posterior roots and relieve pain. A comparison of my Case II with Case IV is most instructive. In both pain was intense, with paralysis occurring after many months, and with no involvement of the bladder and rectum, and yet in the first the tumor was entirely within the dura, and in the other it was entirely extradural, and also in the verebræ.

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[4] Loc. cit.

LESIONS OF THE CONUS. The nerve tracts in the conus occupy a very small space, therefore when a lesion occurs in this part of the cord it is likely to implicate most of the tracts at nearly the same time. As a result paralysis of sensation and implication of the bladder and rectum occur almost simultaneously. If the lesions are strictly limited to the conus, which, following the lead of Raymond, may be recognized as beginning at the third sacral segment, we cannot expect motor paralysis except of the bladder and rectum, inasmuch as the limbs receive their motor supply from the lumbar and upper sacral segments. Pain is not usually a prominent symptom in conus lesions, unless the meninges or posterior roots are likewise affected.

Anesthesia in certain territories innervated by the lower sacral segments may occur in conus lesions and may be dissociated; it may even be bilateral from unilateral conus lesion, in that the buttocks near the anus, the perineum, and the external genitalia may be anesthetic on both sides. This bilateral anesthesia, so limited, is caused by involvement of the lowest posterior root fibers entering the conus on the side of the lesion and by involvement of the corresponding fibers from the opposite side after they have decussated in the conus.

When the lesion is confined to the conus it may by irritation of the adjoining upper region cause not only a zone of hyperesthesia above the anesthetic areas, but exaggeration of the patellar reflexes; yet this exaggeration of the patellar reflexes may occur from tumor of the cauda equina, as in Volhard's case.

Chronic meningitis confined to the lower part of the cord and cauda equina has often been described, according to Schultze, and such a lesion causes severe pain, atrophy, and paralysis, not unlike symptoms of tumor. Schultze[5] excluded meningitis in one of his cases (Case VI) because the symptoms were progressive and in sudden increases, and not affected by antisyphilitic treatment.

Müller[6] thinks that in conus lesions the degenerative atrophy occurs more rapidly and intensely than in cauda equina lesions, because in the latter the nerve fibers are not so completely and so quickly implicated. This is a reasonable supposition. I must agree with Müller when he takes issue with Valentine regarding his statement that there is no improvement in conus lesions. Müller reports spontaneous improvement in one of his cases of cauda equina lesions, and this surely may also occur occasionally in conus lesions. Improvement in cauda equina lesions after trauma is not uncommon. Indeed, Schultze[7] has shown that Valentine's statement is not correct for all cases, as in three of his own cases improvement did occur, but the improvement seems to have been in the regions innervated from the lumbar cord. It is very true, I think, that improvement of the function of the conus in conus lesions is usually unimportant, because the transverse area of any part of the conus is so small that lesion in this part of the cord is likely to destroy the conus in its entire diameter, but it is also true that improvement is usually slight in cauda equina lesions so far as the functions of the conus roots are concerned. Certain symptoms may disappear, but the residual palsy is likely to be persistent.

Another of Müller's cases is worthy of note because of certain unusual features. He believed the lesion to be traumatic myelitis of the conus. The bladder and rectum were completely paralyzed, and yet erection and ejaculation were possible (potentia coëundi et gerandi), as the patient became the father of two children after the accident.

I have had a similar case as the result of injury, possibly to the cauda equina, from muscular strain, although the lesions may have been in the conus:

H. C., a male, aged thirty-one years, was injured eighteen months previously by a bale of cotton falling against the abdomen. He was unable to work about three weeks, but then returned to heavy work, feeling not quite so well as formerly. About a month after returning to work, while lifting a bale of cotton, he felt something give way in the right inguinal region, and at the same time heard a tearing sound. He immediately felt weak, and limped on the right lower limb, but walked home, a distance of about two blocks, and went to bed. After one day he got out of bed, but remained at home about a week. He then returned to heavy work, but has not been quite so strong as he was before the injury.

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[5] Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie, 1903, xii, 163.

[6] Loc. cit.

[7] Deutsche Zeitschrift für Nervenheilkunde, 1894, v, 247.

After the accident he lost control of the bladder, so that when he coughed or exerted himself urine would flow. The condition gradually became worse, until now he has no control of his bladder, and has been wearing a bag about a year. The sexual desire is not weakened, but he refrains from the sexual act because of the dribbling of the urine. He had sexual intercourse successfully six months ago without impairment of ejaculation and erection. During the past two months he has noticed that the rectal sphincter functionates weakly, and that when there is a call to stool it is urgent.

Present Condition. His gait and station are good. The lower limbs are well developed, but the man thinks he is weaker than he was before the accident. The left side of the scrotum, left side of the perineum, and the left buttock near the anus have fully normal sensation to touch and pinprick;[8] whereas the right side of the scrotum, except the upper outer portion, the right buttock, in a small area near the anus, and, to a less degree, the right side of the perineum, show diminution of sensation to touch and pinprick. The right side of the penis is less sensitive to touch and pinprick than the left side. He has no control of the bladder, but can control his bowels, except when they are loose. The sensation of the testicles is normal. The patellar reflexes are prompt. The Achilles reflexes are absent or slight. Babinski's sign is not present. The upper portion of the body is not affected.

Müller refers to a case similar to his own reported by Rosenthal, and also to a case reported by Bernhardt in which the bladder and rectum were paralyzed, although the sexual powers were preserved, except that the muscles for expelling the semen (the ischiocavernosus and bulbocavernosus) were paralyzed, that is, the condition, as Müller puts it, was potentia and libido coëundi with impotentia generandi, and he refers to a case reported by Schiff in which ischuria paradoxa and paralysis of the sphincter ani existed, but power of erection was retained. The loss of function of the bladder and rectum, with preservation of erection and ejaculation, is in favor of a conus lesion, but in my case the lesion probably was in the cauda equina, as the symptoms indicated probably unilateral injury, although a lesion of the conus cannot be excluded.

The conus may be injured, while the surrounding roots escape, as in the cases reported by Oppenheim, Schultze, and Sarbó.

Müller says he was unable to find any cases, with necropsy, of conus lesions without trauma.

Van Gehuchten,[9] from a study of the literature and of a case of lesion of the cauda equina and experimental work, believes that the bladder, rectum, and genital organs may retain their functions to a certain degree even when all the roots of the cauda equina, beginning with the fifth lumbar, are affected. He believes in the existence of a reflex centre for micturition, defecation, and erection outside the cord, but not for complete ejaculation of the semen. The restoration of micturition, defecation, and erection after trauma does not indicate that the conus is intact. The primary centres for these functions are in the hypogastric plexus of the sympathetic system; only the preservation of the anal reflex and of ejaculation indicates anatomical integrity of the conus and its roots. While primary centres for the functions mentioned are in the sympathetic system, other centres for them are in the conus, and are necessary for normal discharge of these functions.

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[8] A year later disturbance of sensation has been noticed on this side.

[9] Le Névraxe, 1903, iv.

I have had the opportunity to study a case of lesion of the cauda equina which bears out these statements. The disturbance of sensation is in the lowest sacral roots. By passing the urine and feces every three or four hours the man exerts a certain control over the bladder and rectum. The discharge is started by voluntary pressure of the abdominal muscles, but the man has no sensation from the flow of the urine, as the urethra is anesthetic. When the urine has nearly ceased to flow he is unable to stop the stream or to expel the last few drops. Erection occurs. There is, therefore, a certain periodicity in this case, but in another under my observation, in which sensory disturbances are also limited to the lower sacral roots, both cases resulting from injury to the end of the spinal column, the urine dribbles without the slightest control by the patient.

Warrington refers to the fact that Raymond has shown that a spinal lesion may cause incontinence of urine without any anesthesia, and Van Gehuchten, that in damage to the conus complete control over the sphincters may be preserved with the urine voided in a nearly natural manner while the mucous membrane of the urethra and bladder are absolutely anesthetic. Erection of the penis was preserved in Van Gehuchten's case, and this, Warrington thinks, is difficult to explain, inasmuch as the penis was absolutely anesthetic, and presumably the sacral centre had been completely destroyed. As he believes the preservation of control over the sphincters may have been due to the activity of the lumbar centre through its fibers to the sympathetic, it should not be difficult to explain the erection in the same way, as this is not always dependent on the sensation of the organ. Ejaculation of semen and forcible expulsion of the last few drops of urine depend on the contraction of the bulbocavernosus and ischiocavernosus muscles, and are always paralyzed if the lowest sacral part of the cord or the corresponding roots are damaged, according to Warrington. It would seem, from Warrington's statements, that these functions are not disturbed by a lesion of the lumbar centre. He refers to Van Gehuchten's statement that it is only with unimpaired capacity for these actions and in the persistence of the anal reflex that the diagnosis of integrity of the conus medullaris and of the corresponding roots can be made. The following points, as Warrington[10] concludes from the writings of Raymond and Sippy, are in favor of a lesion of the cauda equina in distinction from one of the conus.

1. An insidious onset, with general development and progression of symptoms. A lesion in the conus is likely to cause a more rapid development of the symptoms.

2. Pain, violent in nature, spontaneous or excited by change of position or by movement, is in favor of root lesion, though moderate pain may be present in either condition.

3. Pain over the vertebral column below the level of the second lumbar spine exaggerated by percussion and radiating toward the lower limbs speaks for a root lesion. Warrington adds to this rigidity of the lower part of the spine from irritation of the nerves of the dura. Pain higher up, increased by pressure and not radiating very clearly over the lower limbs, is in favor of a medullary lesion. Lasègue's sign is indicative of a root lesion. Asymmetrical development is a radicular symptom, and is, perhaps, especially suggestive of an extradural lesion. My Case II shows, however, that one may be readily deceived in this sign. Remission of symptoms, especially amelioration in the condition of the bladder and rectum, and the slow appearance of muscular wasting, of the reaction of degeneration, and of trophic disturbance are, according to Warrington, in favor of an affection of the cauda equina.

TUMOR OF THE CAUDA EQUINA. The pain in cases of this type is often unilateral at first, but, as a rule, soon becomes bilateral, and yet it may remain unilateral many months. If the tumor develops at the lower end of the cauda equina, it will implicate the nerve fibers supplying the bladder and rectum, causing disturbance of function in these viscera, and disturbance in sensation in the region of the anus from the implication of the lowest sacral and coccygeal roots. This symptom-complex does not necessarily imply that the tumor is so low, because a new growth within the filum terminale near its origin from the cord may press at first upon those roots nearest to the filum, that is, the coccygeal and lower sacral, and cause the same combination of symptoms as when the tumor is considerably lower. This was well shown in the cases of Lachmann and Volhard.

In Lachmann's case of glioma of the upper part of the filum terminale the diagnosis of carcinoma of the bladder was made. The symptoms had existed two years, and began with incontinence of urine, paradoxical ischuria, and retention of feces. Later, digestive disturbances and emaciation developed. Hemorrhage into the bladder, especially with sudden return of the power to empty the bladder, strengthened the diagnosis of carcinoma, as in papilloma of the bladder catheterization by removal of the occlusion of the orifice may cause hæmorrhage and return of the power to empty the bladder. The necropsy revealed catarrh of the bladder, with swelling and injection of its mucous membrane.

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[10] Lancet, 1905, II, 740.

A case of Cruveilhier, reported in his atlas, to which Lachmann[11] refers, shows, however, that a tumor of the filum does not always cause symptoms confined to the bladder and rectum. The symptoms were paralysis of the lower extremities, with contracture, and paralysis of the bladder and rectum. A tumor, which Lachmann thought the picture showed to be in the filum, was found. It was diagnosed as "encéphaloide."

A tumor of the filum, however, may exist without causing symptoms if it is not very large. I[12] reported a lipoma of the filum without any symptom caused by the growth, as the tumor had not attained a size sufficient to cause pressure.

Volhard's case is an exceedingly interesting one. The symptoms developed slowly (during four years), and began with disturbance in emptying the bladder and in sexual power, then dilatation of the bladder occurred with pyelitis, and dyspeptic symptoms, dryness of the skin and mucous membranes, and constipation. The muscular supply of the left sciatic nerve later became weak, and slight hypesthesia was detected in this region. The patellar reflexes were lively and the cremasteric reflex was present on both sides. The Achilles tendon reflex was weak on the left side and absent on the right side. Pain was not felt, and the only subjective sensory disturbance was a feeling of pressure over the sacrum. The absence of pain in this case, in which the symptoms persisted four years, was most extraordinary, and no similar case of cauda compression was known to Volhard, nor have I been able to find any, although tumor elsewhere on the spinal cord without pain has been observed. Operation was not attempted, as the patient's condition became too grave. The necropsy revealed a benign tumor of the cauda equina close to the conus, pressing the roots forward, and thereby injuring the motor roots most, as they were pressed against the bone, whereas the posterior roots were next to the soft tumor. A tumor lower in the cauda, Volhard[13] thought, could not have caused the symptom-complex. The weakness of the left lower limb seems to have been present about two years or a little more, and yet in all this time the right lower limb did not become weak; but a still slower development of the symptoms was present in a case of tumor of the cauda equina observed by Schultze.[14]

In this case pain was felt in the distribution of both sciatic nerves in 1885, and paralysis in the distribution of the right peroneal nerve in the end of 1886, but paralysis in the distribution of the left peroneal nerve did not occur until 1891, five years later. Vesical symptoms did not appear until seven years after the beginning of pain. Operation was attempted and a part of the tumor was removed, but the bleeding was profuse, much cerebrospinal fluid escaped, and the patient died on the eleventh day after the operation. The necropsy showed a large tumor of the cauda equina, an angiosarcoma myxomatodes, that had eaten its way through the bone.

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[11] Archiv für Psychiatrie, xiii, 50.

[12] Journal of Nervous and Mental Disease, 1899, p. 287.

[13] Deutsche med. Wochenschrift, August 14, 1902, Nr. 33, p. 591.

[14] Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie, 1903, xii, 163.

A tumor may implicate both posterior and anterior roots, and for a long time cause only pain, usually in the hips, over the coccyx, and in the distribution of the sciatic nerve. The growth may be quite large, but it will still find space without causing a paralyzing pressure upon the nerve roots. A moderate degree of pressure is, however, sufficient to irritate the nerve roots, and this irritation will usually be shown first in the posterior roots, and therefore as pain, but there may be spasmodic twitching of the muscles of the lower limbs. The paralyses of motion and of sensation are usually later symptoms, and indicate that the tumor has attained considerable size. The paralysis may develop rapidly or within a few days, and in one of my cases of rapid paralysis (Case II) a blood cyst was found at necropsy. This cyst, with its well defined wall, could not have formed within so short a period before death, a few weeks. It is probable that a cyst existed in association with the tumor, and that hemorrhage into the former occurred.

Usually the development of symptoms in cauda equina lesions is very gradual, the symptoms beginning with pain and loss of reflexes in the lower limbs, followed often much later by paralysis and atrophy and anesthesia. The anesthesia is to be sought for especially in the perineum, external genitalia, and in a narrow zone about the anus, as this region receives its sensory nerves from the lowest roots of the cauda; and, although the tumor may not be at the exit of these roots through the sacrum and coccyx, it may exert pressure upon them near their exit from the cord, notwithstanding they are centrally situated in the cauda equina; but it is not true that these centrally situated roots are always first affected, as shown by my Case II, although Müller says it has been demonstrated that in high lesions of the cauda equina the most central nerve roots, those that arise lowest from the cauda, that is, the roots innervating the bladder and rectum, usually are first affected, and he refers to Lachmann in support of this statement; but this combination of symptoms by no means invariably occurs in high lesions of the cauda equina. In Lachmann's case the tumor was in the filum, and therefore in immediate relation with the lower sacral and coccygeal roots.

In determining the level for operation, the highest roots giving evidence of implication should be exposed.

A very interesting case of cauda equina lesion, reported by Müller,[15] shows how difficult the diagnosis between cauda equina and conus lesions may be:

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[15] Loc. cit.

A man, aged twenty-two years, after carrying heavy weights, had severe pain in the lumbar region lasting two days. He then worked fourteen days, when the lumbar pains returned, were severe, and soon radiated into the lower limbs. These limbs, as well as the muscles of the trunk, rapidly became weak; the right lower limb, however, did not become weak until a few days after the left lower limb had become completely paralyzed. Then followed paralysis of the bladder and rectum. Weakness was present in the legs below the knees, but the feet were completely paralyzed. Reaction of degeneration was obtained in the back of the thighs, and in the legs below the knees, and ataxia in the heel-to-knee test was seen. Sensation was greatly affected in the distribution of the sacral roots. The patellar tendon reflexes and Achilles tendon reflexes, erection and ejaculation were lost. The pain indicated a cauda equina lesion, but the rapidity in the development of the symptoms, early cessation of pain, and the complete paralysis of the affected muscles indicated a conus lesion. Dissociation of sensation was imperfect over the scrotum and penis (impaired tactile sensation, loss of pain and temperature sensations), and bedsores developed rapidly; all this made the diagnosis of myelitis probable, but the cord was found to be normal, while the cauda equina was the seat of inflammation. This interesting case shows that at least an imperfect dissociation of sensation may occur in lesions of the cauda equina. Müller was unable to find any case in the literature like this one of his.

One reason why tumor of the cauda equina is likely to cause first sensory symptoms is that at the lower end of the cord the sensory roots are more numerous and larger than the motor roots, as shown by Müller.

When trauma is the cause of cauda equina lesions the symptoms may develop rapidly, as a fracture may implicate many nerve roots.

In the case reported by Laquer[16] pain, sharply localized to the middle of the sacrum, had persisted two years with pain on pressure in the same region. The rectus femoris muscle on both sides was weak and slightly atrophied. There had been transitory vesical and rectal paralysis. The tendon reflexes of the lower limbs were diminished. The sexual functions were impaired. Lumbar kyphosis was present. On account of the great pain by pressure over the sacrum the diagnosis of tumor was made, not within the dural sac, but outside the dura or within the sacrum. Every symptom of bone disease, swelling, displacement of the sacrum, was absent, and disease of the pelvis was considered improbable; therefore the conclusion was reached that the tumor was within the sacral canal. An intradural tumor implicating the cauda equina was considered improbable, as extensive motor, sensory, and trophic disturbances were absent notwithstanding the long duration of the process, and the vesical and rectal paresis was of short duration, except that slight ischuria remained. This case, however, clinically has great resemblance to my Case II, in which the tumor was within the dura.

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[16] Neurologisches Centralblatt, 1891, p. 193.

The entire sacral canal was opened, and a tumor (lymphangioma cavernosum) was removed from about the middle of the sacrum. It was about the size of the little finger, extradural, and not united with the roots or dura, but pressing the dura and cauda equina forward. The pain had disappeared two weeks after the operation, and the patient left the hospital cured four weeks after the operation. The dura was not opened, and possibly the recovery was due to this fact. The case seems to have been a most successful one.

In Laquer's case the pain in the sacrum was intensified by coughing, sneezing, defecation, or by the dorsal position. The absence of pain on pressure over the sciatic and crural nerves was one of the points used in favor of the diagnosis of a tumor beneath the sacrum, but some of my cases show that this pain on pressure over the nerves may be present in cauda equina or vertebral tumors.

A very thorough report of a tumor upon the conus and infiltrating the cauda equina is given by Sailer.[17] A man had severe pain in his lower limbs for some time. His gait had been ataxic six months. The pain commenced in the feet, and in this the case is remarkable, and extended upward, and was more severe in the left lower limb. Diffuse tenderness was present in the lower limbs, and especially over the nerve trunks. The sciatic nerve was more sensitive than the others. Continuous pain and tenderness were felt in the lumbar region. The feet were œdematous. (This condition in Schmoll's case caused him to suspect involvement of the vessels, but exploration of the abdomen did not reveal any vascular obstruction.) Paresthesia was present in the lower limbs, but objective sensation was probably not impaired. The patellar reflexes were absent. The man was able to move his lower limbs, but they were wasted. Later, frequent micturition appeared. A melanotic sarcoma was found in the lumbar region at the necropsy, about one inch in diameter, lying upon the left side of the lumbar enlargement and cauda equina roots. The tumor extended downward to the conus. Its total length was 4 cm., its anteroposterior diameter 1 cm., and its lateral diameter 7 cm. in the widest part. A considerable mass of granular tissue infiltrated the cauda equina. Sailer discusses the rarity of this variety of tumor within the vertebral canal. The spinal cord in the region of the tumor was much enlarged.

In the case of tumor of the cauda equina studied by Schmoll[18] both sciatic nerves were excessively tender. The nerves became so tender that the patient could not lie on the back or abdomen, and to obtain relief was obliged to rest in a kneeling position. In order to sleep he knelt on cushions and reposed his head on the bed. He had rectal crises, with extremely painful tenesmus.

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[17] Contributions from the William Pepper Laboratory of Clinical Medicine, vol. i, p. 129.

[18] Amer. Jour. Med. Sci., 1906, cxxxi, 133.

The bilateral sciatica was of three and one-half years' duration, and the rectum was involved in the painful area without involvement of the bladder. During this period the symptoms had not increased, and were merely those of pain. This is a most extraordinary case in this respect, and affords a remarkable contrast to Volhard's case, also of long duration, in which pain was not felt. It resembles my Cases II and IV. It is not strange that Schmoll could not believe that the lesion was a tumor, and, as the man had pulmonary tuberculosis, he concluded that a slowly progressing inflammation of tuberculous nature was involving the nerves. An "intraspinal" gliosarcoma was found beneath the sacrum, banana-like in form, about 6 cm. long and 2 cm. wide. The statement is made that it was "beneath the dura mater, which formed the floor of the opening;" therefore, it was a tumor of the cauda equina. The patient died on the fourth day after the operation with meningitis and pneumonia.

Schmoll thinks that the interval in his case between the beginning of irritation of the posterior roots and of other signs of compression is the longest on record. The cauda equina at necropsy showed no signs of the longstanding compression. Motor symptoms appear to have been entirely absent, but they did not develop until after many months in my Cases II and IV.

In Valentine's[19] case a prominence was observed over the third to the fifth lumbar vertebræ. A small piece of tissue removed showed the tumor to be a small round cell sarcoma, but neither operation nor necropsy permitted a confirmation of the diagnosis. The two cases of tumor of the cauda equina reported by Sibelius[20] are interesting chiefly from a pathological standpoint.

Schlessinger,[21] in his work on tumors of the spinal cord, gives pictures of a glioma of the conus terminalis (p. 26) at the junction with the filum; of a small cell sarcoma attached to the nerve roots and reaching nearly to the cauda (p. 34); and of an endothelioma of the dura lying upon the cord, reaching to the beginning of the cauda equina, and apparently well defined (p. 39).

The preservation of the sexual functions, even when the sensation of the bladder and urethra is lost, is shown in a case reported by Valentini,[22] in which paralysis of the bladder, with ischuria paradoxa and anesthesia of the penis existed, but the sexual functions were almost intact, except that the ejaculation of the semen into the anesthetic urethra was not noted. Valentini concludes that the nerves controlling the sexual functions must be distinct from the sensory and motor nerves of the bladder and urethra, and other cases referred to in this paper fully justify this opinion,

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[19] Zeitschrift für klin. Med., 1893, p. 246.

[20] Homén's Arbeiten, Band i, Heft 1, 2.

[21] Beiträge zur Klinik der Rückenmarks- und Wirbeltumoren, 1898.

[22] Zeitschrift für klin. Med., 1893, xxii, 245.

In Thorborn's[23] case, with symptoms of extensive lesion of the cauda equina, only a very small tumor, a fibrosarcoma about the size of a hempseed, was found on one of the nerve roots of the cauda equina, with no signs of diffuse inflammation. As Thorburn says, some other lesion must have existed. Operation was not attempted.

In a case of tumor of the cauda equina reported very briefly by Gowers,[24] operation was not attempted. Many nerve roots were involved in the tumor, which was a fibrosarcoma, and from the picture given by Gowers, it could hardly have been removed by operation.

As regards the level of the lesion, the important case of Schultze[25] must be borne in mind. He has shown that a fracture of the twelfth thoracic and first lumbar vertebræ, causing a spicule of bone to project into the vertebral canal in the median line, and thus involving the lower part of the lumbar swelling of the cord, may give a symptom-complex confined to the distribution of the sciatic nerves and lower roots of the cord, providing the upper lumbar roots, situated laterally at this level, are not implicated. In such a case Erb had made a diagnosis of lesion of the cauda equina not higher than the fifth lumbar vertebræ. A lesion, therefore, at the level of the first lumbar vertebra, if it injures the cord alone, may allow the function of the lumbar roots, except, perhaps, of the fifth lumbar, to be preserved; and cause the same symptoms as a lesion of the fifth lumbar vertebra; while a complete transverse lesion, as a tumor, at the level of the second lumbar vertebra, may implicate all the lumbar roots, as well as the sacral, and cause complete motor and sensory paralysis of all the nerve distributions of the lower limbs.

Surgical Intervention. The question of operation is an exceedingly important one in cases of tumor of the cauda equina. Laquer's case is the only one Volhard could find in 1902 of cauda equina tumor correctly diagnosed and successfully operated upon. He found only six cases of tumor high in the cauda equina, and in those the correct clinical diagnosis was not made.

In Laquer's case the tumor was on the outside of the dura, and the latter was not opened. It is not improbable that the success of the operation depended upon this fact. Selberg[26] reports (1904) a case of spina bifida, complicated by a lipoma, implicating both spinal cord and cauda equina. The tumor was removed. Recovery from the operation occurred.

In another case a sarcoma was found at operation compressing the cord and cauda equina. The opening in the vertebral canal was 14 cm. long. The portion of tumor removed measured almost 9 cm.; it was, therefore, a very large tumor. Hemorrhage during the operation was slight, but the pulse was feeble after the operation —84, and death occurred the same day in collapse. The symptoms were not proportionate to the size of the tumor.

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[23] Brain, vol. x, p. 388.

[24] A Manual of Diseases of the Nervous System, second edition, 1892, vol. i, p. 546.

[25] Deutsche Zeitschrift für Nervenheilkunde, 1894, vol. v, p. 247.

[26] Beiträge zur klin. Chirurgie, 1904, vol. xliii, p. 197.

It is evident that the most thorough asepsis must be maintained in operations upon the spinal cord, especially in the lower portion, and this often is difficult, as decubitus and eczema occur, especially over the sacrum, making the opening of the lower part of the spinal canal especially dangerous. The escape of cerebrospinal fluid probably is considerable in the first few days after the operation. Selberg suggests that the patient, after the operation, should be kept with the upper part of his body slightly raised, in order to lessen the danger of pneumonia, and he should lie on one side to prevent the urine running into the bandages. The abdominal position during the operation increases the danger of pneumonia. If this be true, it would be possible to operate while the patient is lying on his side. Selberg says we must acknowledge that only a small portion of spinal tumors are operable, on account of their character and position. The operable tumors are those of the membranes that have not implicated the cord, and are lipomas, fibromas, psammomas, echinococci, and exostoses.

In Sachs' 2 cases,[27] reported in 1899, operation was performed. In the first a tumor (alveolar sarcoma) the size of a small cherry was found adherent to the dura and bone, and compressing the cauda equina. As much as possible of the diseased tissue was removed. In the second case laminectomy of the second and third lumbar vertebræ was performed. A gelatinous mass (small cell sarcoma) was exposed invading the body of the third lumbar vertebra. The tumor was removed. It had compressed the cauda equina. Improvement was pronounced in both these cases, but in neither was the dura opened.

In Starr's[28] case the spines and arches of the second, third, and fourth lumbar vertebræ were removed. An endothelioma involving both the soft and hard tissues was found. The dura seems to have been left unopened. The patient was in a critical condition for two days after the operation, but later improved. The case was reported shortly after the operation.

In the case of tumor of the cauda equina, reported very briefly by Fraenkel,[29] operation was performed, and the patient reacted with difficulty. The tumor was a fibrosarcoma. "Certain symptoms improved after the operation." Death occurred two months later.

The case of tumor on the cauda equina and lower part of the spinal cord reported by Putnam and Elliott[30] has some features of unusual interest. The patient, a woman, had been operated upon for cancer of the breast, and the diagnosis was metastasis to the spinal cord. Removal of the spinal tumor was attempted. An incision ten inches long was made over the lower thoracic and upper lumbar region, and the laminæ of the last thoracic and first two lumbar vertebræ were removed. On opening the canal, a carcinoma was found immediately beneath the bone. It was removed as far as possible, and two nerve roots on each side at the level of the growth were divided outside the dura but within the spinal canal. The dura was not opened. Relief of pain from this operation was very marked, but death occurred after a few months. The authors had entertained the thought of dividing the spinal cord in order to relieve the pain.

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[27] Journal of Nervous and Mental Disease, 1900, p. 108.

[28] Ibid., 1901, p. 156.

[29] Ibid., 1903, p. 101.

[30] Ibid., p. 670.

In the case of tumor reported by Box,[31] the first, second, and third lumbar spines and arches were removed. The dura was red, pulpy, and thickened. The cord appeared to be normal when the dura was opened, but no tumor was found. A piece of dura examined microscopically showed inflammatory changes, with small areas of calcification. The operation was well borne and the wound healed well. Later, a prominence appeared in the neighborhood of the laminectomy scar. A necropsy was not obtained. The tumor was supposed to have arisen in the meninges or the vertebræ, and thereby to have caused root symptoms, which were bilateral from the beginning.

Warrington's[32] interesting case of tumor of the cauda equina was typical in its symptomatology. Operation was performed and a soft-looking tumor was found within the cauda equina. It bled very freely when the attempt was made to remove it, and only a part could be obtained. The tumor was an endothelioma, or hemorrhagic angiosarcoma. Improvement occurred, but symptoms began to return about the end of three months. When a second operation was attempted the tumor was found to have grown enormously and was two to three inches long. A number of posterior roots were divided. The patient made a good surgical recovery after each operation, although in each the dura was opened. The first operation was on September 2, the second about three months later, and death occurred in the following May. At the necropsy the original growth was found to be of very large size, and multiple growths were present in the pia along the whole length of the spinal cord. A similar growth was present in the angle formed by the cerebellum, pons, and medulla oblongata.

The pain in this case is worthy of special notice; it was increased by flexing the thigh on the pelvis (Lasègue's sign), but distinct pain on pressure was not felt over the muscles of the thighs or legs or at the points of Valleix.

Warrington, on referring to the literature on tumors of the cauda equina, says Dufour (1896) collected 21 cases; in only 1 had an operation been performed, and this was successful (Laquer's case, to which I have already referred). At a meeting of the Neurological Society, on October 27, 1904, Warrington says Dr. Ferrier and Sir Victor Horsley showed a patient from whom a fibromyxoma compressing the conus and cauda equina had been removed with marked success.

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[31] Lancet, 1903, II, 1566.

[32] Ibid., 1905, II, 749.

In one of the recent cases of spinal tumor reported by Batten[33] a sarcoma was found at operation outside the dura extending along the left twelfth posterior thoracic root. It was removed. The dura evidently was not opened. The condition of the patient following the operation is not stated.

This review of the literature shows that operations on the lower part of the vertebral column for tumor have been rather discouraging. True, the number of operated cases is small. I leave out of consideration here the successfully operated case of spina bifida, complicated by lipoma, reported by Selberg, and others of this character are known. The conditions in spina bifida are not the same as in tumor of the cauda equina.

Death occurred following operation in the cases of Selberg, Schmoll, Schultze, and cases of my series, I, II, and IV, although in the latter the tumor was extradural. Operation was not attempted in the cases of Cruveilhier, Volhard, Valentini, Sailer, and of my Cases III, V, VI, and VII. It was of benefit in the cases of Sachs, Starr, Fraenkel, Putnam and Elliott, Ferrier and Horsley, and Warrington; but Warrington's seems to be the only case in which the attempt to remove a tumor of the cauda equina did not result fatally, and the amount of improvement in this case is questionable. Opening the dura where a tumor of the cauda equina exists seems to be a serious undertaking.

We should like to accept the opinion of Müller when, in discussing tumors, he says that the prognosis from surgical intervention on the sacrum and lumbar vertebræ is decidedly better than on the other vertebræ and cranium, but statistics are not yet sufficiently large to warrant this statement. In my own cases, when the tumors could be examined they were all of such a character that complete removal would have been impossible, and this seems to have been true of most, if not of all, recorded cases. The well-defined, almond-shaped fibromas or fibrosarcomas occurring frequently at higher levels of the cord are much less likely to develop in the region of the cauda equina. Volhard regarded the tumor in his case as a glioma, although it was external to the cord, but intradural. He expressed the opinion that the tumors of this region that have been described under various names are all of the same character, and possibly are congenital; but, so far as I can judge from my own experience, they are usually sarcomas, and very often infiltrate about the roots of the cauda equina, or implicate the surrounding bone. The tumor in my Case II was a fibrosarcoma, but not like the sharply defined tumor of this character often found at higher levels of the cord.

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[33] Lancet, 1907, I, 139.

If the prognosis at present is very gloomy, in operating for tumor at the lower part of the vertebral column, it may be possible at least to cut posterior roots in order to relieve pain. It is not easy to determine the individual roots presenting in the opening formed by the exposure of three vertebræ. When the dura is incised the roots appear in contact with one another and they cannot be traced except in a very imperfect manner to their point of origin in the cord, or to their point of exit through the dura. The uppermost roots presenting in the opening are, of course, the sensory, and by observing whether the roots pass toward the posterior or the anterior part of the cord it may be possible to determine whether they are sensory or motor. If the attempt is made to divide all the sensory fibers of any one root, it is probable that some motor fibers will be included and may be cut, but it is doubtless unnecessary to cut every sensory fiber of any one root in order to relieve pain.

The roots of the cauda equina descend far within the dural sac, but on leaving the dura they pass only a little way downward before entering the intravertebral foramina; the sacral roots, however, have a longer extradural course than the lumbar. Having determined the lumbar vertebræ, each root at the lower border of a lumbar vertebra has the same name as the vertebra immediately above it, and we may, therefore, recognize it, and by tracing its course into the dural canal the sensory fibers may be separated from the motor.

If the opening in the vertebræ is high enough to permit exposure of the end of the conus, the second lumbar root may be determined by finding the first root leaving the dura below the conus; in the adult this is the second lumbar root.

The sensory roots supplying the bladder and rectum are at the interior of the cauda equina, near the conus, and it may be possible to leave these uncut. In cases in which the bladder and rectum are not paralyzed great care should be taken in cutting posterior roots to avoid the roots to the bladder and rectum, as paralysis of these important organs is a most undesirable complication. A few cases in the literature in which the posterior roots of the cauda equina have been cut to relieve the pain of tumor are referred to in this paper. It is permissible only when the tumor is irremovable and the pain is intense.

ORIGINAL OBSERVATIONS.

CASE I.—The first case of tumor of the cauda equina which I have studied was in the service of Dr. Dejerine, at the Salpêtrière.[34] This case was reported in 1895 by Dr. Dejerine and myself, more, however, as an anatomical and pathological study. The tumor was a round cell sarcoma. The patient had had pain and paralysis in her lower limbs eighteen months, implicating chiefly the right side. The operation was performed by Chipault. The third, fourth, and fifth lumbar and first sacral vertebræ were operated upon, and the tumor was found within the dural sac implicating the roots of the cauda equina. Hemorrhage was profuse, and the operation was abandoned. Death occurred three hours later, and at the necropsy the lower vertebræ were found implicated by the tumor.

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[34] Comptes-rendus des séances de la Société de biologie, séance du 27 Juillet, 1895.

CASE II.—Mrs. E., about fifty years of age, was first seen by me August 7, 1906, in consultation with Dr. N. L. Knipe, at which time the following notes were made: Pain began in the left hip one or, possibly, two years ago, but at first occurred only occasionally. In February, 1906, the pain in the left lower limb began to be severe, and Dr. Cleveland was called to see the patient. In about two weeks after the pain had become severe in the left lower limb, it was felt in the distribution of the right sciatic nerve, but here it lasted only a few days. Dr. Cleveland, when he first saw the patient, regarded the pain in the left limb as sciatica, which it resembled. The pain has persisted until the present in the left limb. Mrs. E. has always had a tendency to constipation, but this has been more pronounced during the past year. She was catheterized during one or two months while in the Presbyterian Hospital in the spring of 1906, but not since, and the retention of urine was attributed to the patient being in bed. Whether or not it was a transitory paralysis of the bladder is uncertain. Pain has been felt since February, 1906, at the end of the spinal column deep in the tissues and extending upward to about the lumbar region, but not above this. Periods of improvement had occurred. The pain came on in attacks and was very severe, and was chiefly over the sacrum and coccyx, but she has had some severe pain down the front of the left thigh. Pain was seldom in the right lower limb. It was through the left hip, but not in the right hip.

Present Condition. She has no motor weakness, no atrophy, no objective sensory changes in the lower limbs, no points of tenderness over the sacrosciatic notch, or over the sciatic nerves in the limbs. Lasègue's sign is not present, as no pain is produced by overflexing either lower limb. The left patellar reflex is diminished; the right is about normal. The Achilles-jerk is weak, but present on each side. The patient has not been out of bed for months on account of the pain. She can move either lower limb freely.

Tumor was the diagnosis made by me at this time, but the absence of motor paralysis and the almost unilaterality of the symptoms made the diagnosis a guarded one. Multiple neuritis was possible, but the severe attacks of pain and the absence of tenderness to pressure over the nerves were not in favor of this diagnosis. Vaginal and rectal examination were advised.

Dr. Knipe informed me, on August 30, 1906, that the patient had had none of the agonizing attacks of pain since she was seen by me, but this was not unusual, as these attacks had in the past recurred after long periods of comparative comfort. Dr. John Hirst made a vaginal examination, but could discover no tumor of the pelvis, no enlargement of the sacral bone, and no other abnormal condition except a deflection of the uterus to the left side and adhesions on that side. He thought this might be sufficient to cause some pressure upon the sacral roots. The patient had been complaining of great soreness in the back, especially in both buttocks and thighs.

She was seen again by me October 23, 1906, in consultation with her physician, Dr. Cleveland, when the following additional notes were made: She has had severe pain in the right lower limb about two months, but the pain in the left limb has become less severe during the past few weeks; she has had pain down the front of each lower limb, as well as down the back of the limbs. The pain has been severe in each lower limb and like toothache. Both legs below the knees feel numb, and she has a sensation as of a band about the right ankle. Since last week she has become weak in her lower limbs, but was not so previously. She has had some rise of temperature a long time, and has cystitis with albumin and casts.

Present Condition. Sensations of touch and pain are normal in all parts of the lower limbs; sensation of touch is normal about the anus and vulva and in the perineum. She can flex each thigh at the hip very little, but has more power in the legs than in the thighs. The voluntary power at the knees, ankles, and toes is better than at the hips, but is not normal. The patellar reflex is lost on each side. She has no Babinski sign, and the plantar reflex on each side is uncertain, if present. The lower part of the sacrum may be more tender to pressure, but tenderness to pressure is present over the spine as high or higher than the lumbar region. She has no girdle sensation. The muscles of the calves are a little tender to pressure. As objective sensation was normal and micturition and defecation were not much, if at all, affected, it seemed to me that the tumor could not be within the substance of the cord, nor could it have destroyed any of the roots. It probably involved the lower lumbar and upper sacral roots chiefly.

She was examined by me again in association with Dr. Frazier, November 9, 1906. The following notes were then made: The movement of the toes is performed fairly well on each side, but not with normal force. She can flex the right ankle very well, but has very little power in the left ankle. She can raise the right knee from the bed better than the left. The voluntary power at the knees is less than that at the toes. She is very weak, also, at the hips. Sensations of touch and pinprick are normal everywhere, even in the perineum and around the anus. The patellar reflex and Achilles tendon reflex are completely lost on each side, even with reinforcement. She has no involvement of the bladder and rectum. Pressure over the lumbar vertebræ gives more pain than anywhere else over the vertebræ. Movement of the lower limbs causes no pain in her spinal column.

Urinalysis. Cloudy, straw color, flocculent precipitate; neutral, 1008; albumin and sugar, negative. Under the microscope: a trace of mucus, a few white blood cells and red blood cells, a few mixed epithelial cells, few leukocytes, oxalates with triple phosphates.

Blood Examination. Hemoglobin, 90 per cent.; red blood cells, 5,440,000; white blood cells, 8960.

November 10, 1906, an operation was performed by Dr. C. H. Frazier. A horseshoe incision was made in the midline, with the base at the lower border of the first lumbar vertebra, exposing the structures from the first to the fifth lumbar vertebræ. Laminæ and transverse processes of the fourth lumbar vertebra were removed, then those of the third, and finally those of the second. There was no sign of tumor outside the dura. Nothing abnormal was observed, and no adhesions were found between the dura and the vertebræ. The dura was slit in the length of the opening in the three vertebræ. A blood clot was removed from within the right side of the dura, about one inch long, one-quarter inch wide and flat, and having a red gelatinous appearance. A soft, friable mass was seen connected with this clot, within the dura, more on the right side and opposite the body of the third lumbar vertebra. It was about one-half inch in diameter each way. The cord pulsated after the roots of the cauda equina were separated. Only a small quantity of cerebrospinal fluid escaped. All the tumor found was removed, but in pieces. There was no growth outside the dura. The dura was closed with three or four interrupted catgut sutures. The muscles were closed with continuous catgut sutures and the skin was sutured with interrupted silkworm-gut sutures. A cigarette drain was introduced down to the dura through a stab wound in the flap of the skin.

A day or two following the operation the pain in the lower limbs was intense, and weakness of these limbs was increased; but by the fifth day after the operation the pain was much less than before the operation, and the patient could draw up the lower limbs as well as before the operation, and move the left ankle and right lower limb better than before the operation. She died on the morning of November 25. The spinal cord was removed in my presence a few hours later. A cyst, almost empty, was found by the side of the lower part of the conus; it was about the shape and size of an almond and was ruptured at the lower end. The clot of blood removed at the operation probably came from this cyst. Some tissue was found within the cyst that looked like tumor, and a small mass of tissue, looking like tumor, about 2 x 4 mm. in size, was found on the roots where the tumor had been removed, that is, about opposite the third lumbar vertebra. No evidence of infection was detected.

The cyst (Fig. 1) extends within the roots of the cauda equina a half-inch upward above the termination of the conus, and is one inch long and half an inch wide. It does not implicate the roots of the lower part of the conus, and, probably because of this, the bladder and rectum escaped. These lowest roots are caught in the small mass of sarcoma tissue still remaining. The tumor is a fibrosarcoma.

In this case the pain began in the left hip. Müller says that the outer and posterior parts of the pelvis are supplied by the iliac branch of the iliohypogastric nerve and the lateral cutaneous nerve of the thigh, from the lumbar plexus (second or third lumbar, according to his chart). Later, the pain was felt in the course of the left sciatic nerve (first and second sacral according to chart), and the right sciatic was affected temporarily and later permanently. This meant extension to the sacral roots. Still later, pain was felt down the front of each lower limb (fourth and fifth lumbar, according to chart). This part is supplied from the lumbar plexus. The patient had a sensation of numbness in both legs below the knees, therefore in the sciatic distribution (first and second sacral, according to chart). She also had pain at the end of the spine. This part is supplied from the lowest sacral and coccygeal (fourth and fifth sacral) roots. The weakness in the lower limbs meant involvement

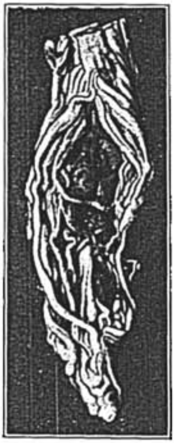


FIG. 1.—Fibrosarcoma and blood cyst in the cauda equina. Vesical and rectal symptoms were not present, although the tumor was in the centre of the cauda equina.

of lumbar motor roots, and the greater power of the legs, as compared with that of the thighs, meant less involvement of the anterior roots forming the sacral plexus, than of those forming the lumbar plexus. Loss of patellar reflexes meant lumbar involvement also. Important was the escape of the nerves for the bladder and rectum (fourth and fifth sacral, according to chart), and absence of all objective disturbance of sensation. The symptoms pointed to a lesion beginning on the left side, then extending to the right side, and involving the second, third, fourth, and fifth lumbar, and first and second sacral roots, the posterior more than the anterior. Pain alone at the end of the coccyx suggested the involvement of lower sacral nerves, but the escape of the bladder and rectum showed that such involvement if it had occurred must be slight. The tenderness to pressure was not strictly localizing, as it was felt both over the sacrum and the lumbar vertebræ. It did not seem probable that the tumor was in the center of the cauda equina, as the bladder and rectum escaped. It might be a tumor on the outside and upper part of the cauda equina not affecting the innermost nerve roots (third, fourth, and fifth sacral and coccygeal; escape of bladder and rectum); this would be indicated by the involvement of the second and third lumbar, and, later, of the first and second sacral, and fourth and fifth lumbar. It must, if within the dura, be high enough to catch the second and third lumbar roots, and if so it could hardly be a very long tumor or it would extend downward far enough to catch the lower sacral roots; nor could it be a very large tumor, as, at the exit of the second and third lumbar, it would press upon all the roots of lower origin and cause paralysis of them; or, possibly, by extending upward, might press upon the conus, in which case paralysis of the bladder and rectum would be likely to occur. It might well be a tumor of the lower lumbar and upper one or two sacral vertebræ; this would explain the escape of the bladder and rectum and the extensive area of tenderness to pressure over the sacrum and lumbar vertebræ. The second and third lumbar roots could hardly have been involved at their exit from the cord, as the implication of the fourth and fifth lumbar and first and second sacral would imply in that case a large tumor, and this would probably cause pressure upon the cord sufficient to produce more impairment of function. It was evident that none of the sensory roots was completely destroyed, as even to the time of operation no objective disturbance of sensation was found. For localization in operation, the second, third, and fourth lumbar seemed to be the proper vertebræ. The blood cyst probably caused the rather rapid development of paralysis in the lower limbs.

Case III.—H. was seen by me July 31, 1905, in consultation with Dr. MacLeod and Dr. Edward Martin. He had also been seen by Dr. Alfred Stengel and Dr. Charles K. Mills. My notes, made July 31, 1905, are as follows: In the early part of 1905 he had a fall on the ice and came down heavily on the buttocks. About three months ago he began to have pain in the lumbar region and down the left lower limb, following the sciatic nerve. In about four or five weeks the pain was felt in the course of the right sciatic nerve. The case was supposed then to be one of double sciatica, and the patient was sent to Hot Springs, Virginia. All venereal disease is positively denied, and the wife has had no miscarriages. While at the Hot Springs he found that the urine did not come promptly, and gradually retention developed, and he had to be catheterized, and his bowels became constipated. Then weakness of the lower limbs developed, and gradually became a complete paralysis. He thinks he has had some pain down the front of the thighs. Dr. MacLeod, of Bryn Mawr, who has been attending him, says that the patellar reflexes at first were very prompt. He has had no involvement of the upper limbs or of the face, but has had tachycardia; pulse, 130. He has lost flesh, is very pale and sickly looking. The paralysis of the lower limbs has developed within about three months. He has been taking 105 grains of potassium daily and as much as 6 ounces of mercurial ointment daily, and has stood this treatment well.

Present Condition. He has complete motor paralysis of the lower limbs, and cannot move the toes or the limbs at the hips. The patellar reflexes and Achilles reflexes are completely lost, even on reinforcement. The Babinski sign is not present, and there is no movement of the toes in either direction. The upper and lower limbs are emaciated. Sensations of touch and pain are lost below the knees and in the posterior part of the thighs, or, if not lost, are almost so; occasionally he seems to have a little sensation in the soles of the feet. Sensations of touch and pain are preserved in front of the left thigh, but are diminished, especially in the front of the right thigh, and are normal over the abdomen to the inguinal region, but are lost or nearly lost over the buttocks about the anus. There is some tenderness over the spine in the lumbar region, but no deformity of the spine. The cremaster reflex is lost on each side. Grasp of each hand is good. The biceps jerk on each side is prompt. The pupils are equal, and respond promptly to light. The facial nerves are not affected. The tongue and muscles of mastication are normal. The man remained in this condition, gradually losing strength, until his death, on September 30, 1905, 1 A.M. Necropsy was held by me September 30, 3 P.M.

The laminæ of the lower lumbar vertebræ were so soft they could be cut with a knife. The anterior portion of the dura was adherent to the bodies of these vertebræ, which also were soft. A mass of tumor tissue was removed, adherent to the anterior part of the dura. Numerous hard, bony-like masses were found in the roots of the cauda equina, and most of these were in the roots where they penetrate the dura; some were within roots in the dural cavity (Fig. 2). These masses, though hard, could be cut easily with a knife. No tumor was found within the cord or within the abdominal cavity. The bedsore over the sacrum was nearly round and about four inches in diameter, and extended to the sacrum. Sores also were over both heels. The lower limbs were wasted.

The tumors both within and without the dura contain numerous calcareous areas resembling imperfect bone formation; within them are many round or oval cells, and in some places spindle-shaped cells like those of a fibroma. They have the appearance of an osteosarcoma. Calcareous deposits and sarcoma cells are found in one of the tumors of the nerve roots within the dura examined microscopically.

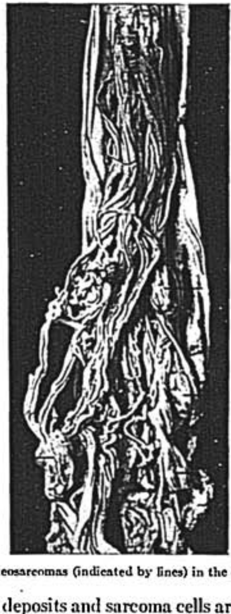


FIG. 2.—Osteosarcomas (indicated by lines) in the cauda equina.

Sections from the lumbar segments stained with thionin show much degeneration of the cells of the anterior horns, chromatolysis, peripheral displacement of the nucleus, and loss of dendritic processes (Fig. 3). The posterior columns in sections from about the twelfth thoracic region show intense degeneration by the Marchi method. Some diffuse degeneration is present in the anterolateral columns, and the posterior roots from this level are much degenerated.

CASE IV.—H. H., aged fifty-five years, was seen by me in consultation with Dr. L. Loeb, September 4, 1905, at which time I made the following notes: He has been having pain in the right thigh about one year, and, although he has occasionally had pain in the left thigh, it has only been within the last two months that he has had severe pain in this thigh. The pain now is over each sacrosciatic notch and is excruciating and comes independently of any movement. Coughing or deep breathing increases the pain greatly. There is no implication of the upper limbs or head. Sensations of touch and pain are normal in the lower limbs. The patellar reflex is prompt on each side, and is shown not so much by jerking of the leg as by contraction of the quadriceps muscle, and it is prompter on the right side. Achilles reflex is not present on either side. There is no Babinski reflex, and the toes are not moved distinctly in either direction. There is no distinct tenderness to pressure over the muscles of the calf, thigh, or anywhere else; nor over the nerves, except, possibly, at the sacrosciatic notch. Some slight tenderness to pressure is felt over the lumbar region. The spinal column is not deformed. He has control of the urine and feces. There is no localized atrophy, although he has lost flesh generally. The pain seems now to shoot down the legs, following the sciatic nerves, and extends to the feet, and movements of the patient cause pain. The lower limbs have good voluntary power, and whatever apparent loss of

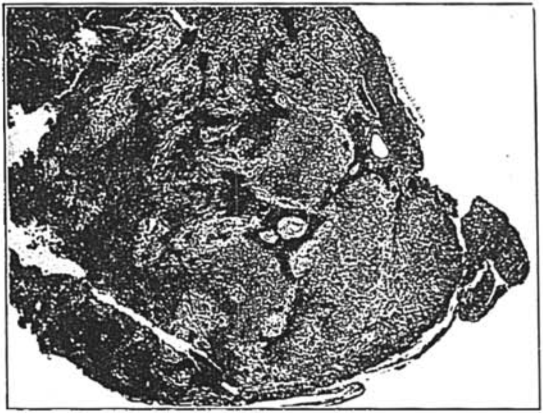


FIG. 3.—Osteosarcoma in one of the roots of the cauda equina. The dark patches indicate calcareous deposits.

power there may be is probably because of the pain. The pain, by extending from the front of the thighs to the back, and in being bilateral, suggests pelvic tumor.

Additional notes were obtained from Dr. W. W. Keen.

December 5, 1906. In the summer of 1903 he fell about four or five feet while building a dam. His knees caught between some rocks and stopped his fall forward, and he fell backward, but did not strike the end of his spine or injure himself in any way, excepting that his knees were bruised by the rocks.

He had drunk quite freely in past years. About eighteen months to a year ago (a little longer than in the statement made to me) he began to suffer pain in the right sciatic nerve. Some months later in the left sciatic; later still, the pain involved the anterior crural, first on the right side, and later on the left side. He has had also some diffuse pain in both hips. The pain has been progressive, but has been worse of late on the left side. He has had some obscure sacral pain, but none in the lumbar region. About four or five weeks ago he began to lose power in the lower limbs, first in the right leg, then, about three weeks ago, in the left leg, after a severe attack of pain. The bowels and bladder have never been involved in any way. There is no local muscular wasting.

When Dr. Eshner first saw this patient about four weeks ago the patellar reflex on the left side was absent; on the right side it could just be elicited; both of these tests being with reinforcement. There was no plantar reflex. Babinski's sign on the left side was doubtful. Cremasteric and anal reflexes were normal. The man has never had any fever excepting two months ago, when for three or four days his temperature ran up to 103° from some temporary gastric disturbance. Bowels are regular. An *x*-ray photograph showed no alteration. There has been no loss of sexual power, but inability to perform the sexual act on account of pain.

Dr. Harvey Cushing, in examination of the pelvis, found nothing wrong. Dr. Keen found that the cremasteric reflex was elicited only on the inside of the thigh, but was quite well marked on both sides. The patellar reflexes were absent, and there was no Babinski reflex. The man could voluntarily draw up both legs well, the right more forcibly and quickly than the left, which moved feebly and after repeated efforts. He could stretch out both legs, the right better than the left. Examination of the back showed no tenderness in the lower dorsal, lumbar, or sacral region either upon pressure or sharp percussion with the fingers. Mercury and potassium iodide had been used to the limit of tolerance.

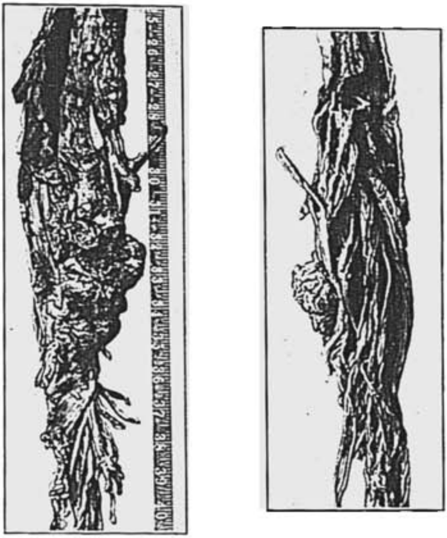
On December 9, 1905, a consultation was held with Drs. Mills, Eshner, Keen, and myself, at which time the following notes were made: In the left leg foot-drop is almost complete. Whether this was true four days ago Dr. Keen did not know. There is no Achilles-jerk on either side. Voluntary flexion and extension of the toes and ankle on the right side are present, but, except in very slight movement of the toes, are absent on the left. The movements are very weak in the whole left leg. On the right side they are impaired, but much less so than on the left, and are worse below the knee than above. There is no anesthesia anywhere. On the dorsum of the left foot there is very slow appreciation, with slight diminution on the left thigh posteriorly. Sensation on the scrotum is normal. On passively moving the right leg considerable pain is felt in the sacral region. Moving the left leg, the pain is much more acute in both legs. It is especially elicited by flexing the leg on the thigh and the thigh on the pelvis with the thigh in abduction. Grasping the muscles of the anterior part of either thigh and compressing them elicits considerable pain on each side, but more on the left. Squeezing the foot on either side is especially painful, particularly so on the left. There is no pain or muscular disability in the arms. The back is rigid. The man was made to sit on the side of the bed, and this position produced marked pain in and about the right trochanter; in the joint, as he expressed it. The pain also extended over the right buttock and sacrum. The conclusion was reached that the lesion was probably either a neoplasm in the spinal canal, most likely in the cauda equina, or possibly a pelvic sarcoma, which, in consequence of the patient's large form and great stoutness, could not be detected. Laminectomy in the lumbar region was decided upon.

Operation December 10, 1905. Dr. Keen removed the laminæ of the first, second, and third lumbar vertebræ. The dura was divided the length of the wound. The tumor was not found. The temperature rose to 101° within a few hours after the operation, and fluctuated between that and 102° until he died at 1.45 A.M. on the 12th, about forty hours after the operation. Œdema of the lungs set in speedily after the operation, and the patient gradually lost consciousness. His pulse rose to 156, and later became uncountable. The necropsy was made by me.

A tumor was found on the anterior part of the spinal dura. It begins just above the exit of the second lumbar roots from the dura and extends to the exit of the third lumbar roots, and is more on the left side in its upper part, but not in its lower part. The cord appears somewhat swollen just below the portion exposed at the operation. The dura was adherent to the bodies of the vertebræ just below the part exposed at operation. The bodies of two or three vertebræ at the level of the tumor were soft and could be partly penetrated by the knife. The tumor seemed to have originated in the bodies of these vertebræ. The stitching of the dura ended just above the upper part of the tumor (Figs. 4 and 5).

The tumor contains round and oval cells and also spindle-shaped cells, with considerable fibrous connective tissues, and has the appearance of a fibrosarcoma. The nerve cells of the anterior horns in the lower lumbar and upper sacral region show intense degeneration, peripheral displacement of the nucleus, chromatolysis, loss of dendritic processes, and vacuolation. The alteration of the cells is equally intense on both sides of the cord.

Sections from the fourth lumbar segment show intense degeneration of the left posterior column by the Marchi method, and of the posterior root fibers entering at this level, but only a slight degeneration of the right posterior column. The degenerated fibers are found also in the left anterior horn. The degeneration by the Marchi method is very slight at the first sacral segment, but is more pronounced on the left side. It is more pronounced at the third sacral segment, and here also is greater on the left side, but is not nearly so great as at the fourth lumbar segment.



FIGS. 4 and 5.—Extradural fibrosarcoma over the roots of the cauda equina. The stitching of the dura ends just above the tumor, shown as a mass of tissue on the outside of the dura.

CASE V.—The notes and pathological material of this case are obtained from Dr. Charles K. Mills. S. D. C., aged sixty-two years, white, male, living at Kennett Square, Pennsylvania, was seen by

Dr. Mills in consultation with Dr. U. G. Gifford, March 15, 1902. He was well until August, 1901, when he first had pain in the back and along the distribution of the left crural nerve and the thigh. He gradually lost power in the left leg, and before this loss was complete the right leg also became affected, the loss of power gradually increasing until, by December, he was almost completely paralyzed in both lower extremities. He had more or less diffuse pain in both legs, but this was most marked in the anterior portion of the left thigh. Early in the case there was tenderness as well as pain in the distribution of the left crural nerve. In December, 1901, and January, 1902, he complained of much pain in all parts of the legs. This pain was not only subjective, but he had much pain on movement of the legs and trunk and also in spots on handling the legs. Taking hold of the legs about the ankle, for instance, would cause him to cry out with pain, and this without any movement of the limbs or body. Later, the pain on handling became less, but he continued to suffer with severe pain in the back, and also with pain which radiated from the back and down the limbs. From about the middle of December his bowels began to be inactive, and in a short time were completely torpid or paralyzed. Later, about the middle of February, incontinence of the sphincter ani came on, and he had at times involuntary evacuations. He never lost control of the sphincter of the bladder, nor were the bladder walls paralyzed, although he occasionally had some apparent difficulty in completely emptying the bladder. He was catheterized by Dr. Gifford, who found no residual urine. Sensation was retained, except, perhaps, on the inner anterior aspect of the thighs, where he was slightly hypesthetic. He had no girdle sensation.

When examined by Dr. Mills, March 15, 1902, the man was in bed on his back and unable to move without assistance. The movements of the thigh on the pelvis and extension of the leg on the thigh on the left side were completely lost; on the right side the conditions were similar, but the loss of power was not so complete. The anterior aspect of the left thigh showed marked atrophy, and no responses to the faradic or galvanic current could be obtained in the quadriceps and other muscles of this aspect of the limb. The same was true on the right side. The movements of the foot were preserved, but impaired, and this was especially true on the left side, that is, he could dorsally flex, extend, adduct and abduct the foot and perform various movements of the toes, but these were impaired and somewhat uncertain, especially on the left. The muscles below the knee were somewhat wasted, but not distinctly atrophied, and responded to the electric current, but there was some quantitative diminution. Sensation was retained, except the slight partial loss over the anterior aspect of the thigh, where the responses were somewhat uncertain. The bowels and bladder were as above noted. Knee-jerks and quadriceps jerks were abolished; no clonus was obtained; he had the Babinski reflex on the left side, and on the right side there was no reflex movement of the toes. At this time the man still complained of much pain in the back and at times of pains radiating to the groin and into the limbs. He was not tender to pressure over the nerves of the extremities, and pain was not caused by lateral squeezing or other manipulations of the foot. The spine was rigid, all movements being restricted. Jarring caused some pain. Percussion and deep pressure caused pain over the position of about the second and third lumbar vertebræ, where there was a slight deformity. He had no symptoms above the waist line.

The movements of the right foot and leg were as noted at the time of this examination, but a few weeks previous to this the loss of power had been greater, and was then somewhat more marked on the left side. Under treatment he had regained in part the movements of the foot on the left side, but no improvement took place in the muscle groups above the knee.

About the 16th or 17th of the month his temperature began to rise; he had frequent and profuse sweating; he sank into a torpid and eventually into a typhoid state; at times he was delirious; he gradually became weaker, and died March 25.

The necropsy was held ten hours after death by Drs. Gifford, Reynolds, and Darlington. In opening the spine the left transverse process over the third lumbar vertebraæ was seen to be necrosed. It was loose and dropped out; no pus was present. The posterior arches were removed from the twelfth thoracic vertebra to the sacrum; the layer of fat and cellular tissue between the periosteum and dura was normal, except at the first, second, and third lumbar vertebræ, where it was replaced by what appeared to be a growth, at least, by a reddish, fleshy-looking mass (Fig. 6). The dura was congested, and the spinal fluid was turbid and bloody. Examining the bodies of the vertebræ laterally and in front, they were found to be decidedly diseased, especially on the left side and in front. Pus, with broken-down bone, could be seen and felt. Between the dura and the bone was a large fleshy mass. This occupied the position in front and on each side of the cord. The cord itself was intact, although probably considerably flattened. Permission was given to remove the cord and attached mass, but not the bone.

Microscopic examination of the extradural tumor showed it to be an endothelioma.

CASE VI.—Probably tumor of the cauda equina. Mrs. E., aged fifty-two years, was seen by me in consultation with Dr. S. Stalberg in the beginning of 1906, from whom the following history was obtained: She was born in Russia. Family history negative. Occupation, ordinary housework duties. She has had eleven children, of whom nine are living, and has had no miscarriages. She has never been sick, except many years ago, when she had hemoptysis during pregnancy. No rheumatism or tuberculosis has occurred in the patient or family. Present illness began about five months ago, with pain and tenderness over the right sciatic nerve at its point of exit from the innominate bone. This was followed in two months by the same condition in the left side, though on the right side the pain was always more severe. At the end of the third month of her illness she had quite profuse uterine bleeding lasting three or four days, her menopause having occurred two years previously. This bleeding was followed by another in two weeks. A vaginal examination was made by Dr. Dorland, who attributed bleeding to an eroded cervix, but he was unable to find either uterine cancer or any other pelvic condition causing the "sciatica."

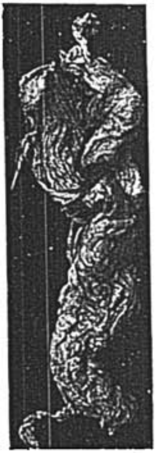


FIG. 6.—Endothelioma on the outer part of the dura over the cauda equina. The tumor has been cut through.

Almost all of the antirheumatics and analgesics, nitroglycerin, potassium iodide, mechanical means, such as splint (for a few days) and compression, bloodless stretching, were tried, but without success. The pain became intense, extending to the muscles of the thigh and to the knee and back.

Notes dictated by me on February 6, 1906, are as follows: She is in great pain. Passive extension of the lower limbs causes much pain. The lower limbs are not greatly wasted. She can flex either leg at the knee to about the normal extent, but can flex either thigh at the hip only partially, and she prefers to lie with thighs partly flexed, in order to avoid stretching the sciatic nerves. The patellar reflex is present, but diminished on each side; she has no movement of either leg on the thigh, and merely slight contraction in the quadriceps muscle, which is weaker on the left than on the right side. She cannot be tested for tactile sensation on account of the difficulty to make her understand. The Achilles reflex is present on each side, but diminished. The muscles of the calf and thigh seem to be somewhat tender to pressure, but it is impossible to tell to what extent. She seems to have voluntary movement of the feet. She complains of some pain in the lower part of her abdomen, but the abdomen does not seem to be at all tender to pressure. The muscles of the abdomen are so flaccid that it is impossible to determine any abdominal reflex. There seems to be no tenderness over the spinal column, and no deformity of the vertebræ. She has no disturbance of the bladder and rectum.

February 27, 1906. Extension of the right leg on the thigh, or left leg on the thigh, causes pain as soon as the leg is almost fully extended. The patellar reflex is much diminished and apparently lost on each side. Achilles-jerk on either side is much diminished. Muscles of calves are very flabby, but pressure of them does not seem to cause intense pain. She has great difficulty in flexing either thigh on the abdomen. She can move either leg on the thigh much better than she can move the thighs. She has no Babinski reflex. Pinprick is perceived in both legs. There is no disturbance of sensation around the buttocks or in either lower limb, objectively tested by a pin. She says the spinal column is tender to pressure in the lower part, but this tenderness cannot be tested positively. It cannot be determined whether there is any diminution of sensation or not. Any turning of patient in bed causes great pain, and the sciatic notch is very tender.

March 26, 1906. The lower limbs are weaker than they were when she came to the hospital, especially the right. Sensations of touch and pain are normal in the lower limbs. The patellar reflex is greatly diminished on each side, or even lost. The Achilles reflex is prompt on the left side, lost on the right. She still has perfect control of the bladder and bowels. Muscular atrophy is present in each leg, especially the right. Babinski's sign cannot be determined, because of resistance of patient. She has some tenderness to pressure in the lumbar region, but no deformity.

The patient left the hospital, and Dr. Stalberg informs me that she died about May, 1906, six weeks later. She was not under his care at that time, but her symptoms during these last weeks of her life were about the same as during the previous period.

Operation was not desired by the patient, and a necropsy was not permitted.

CASE VII.—This patient, a woman about forty years of age, was seen November 1, 1906. She had had signs of pulmonary tuberculosis, and had had for some months pain in the right lower limb and in the lumbar region. About October 24 she had become rapidly paralyzed in both lower limbs.

The notes of her condition at my examination are as follows: The lower limbs are completely paralyzed, with the exception of slight movement at the hips. The muscles of the entire limbs are slightly sensitive to pressure. The patellar reflex and Achilles tendon reflex are completely lost on each side. Babinski's reflex is not obtained. Pressure over the muscles of the calf causes no movement of the big toe. There is no control of the bladder or bowel. Sensation of pinprick and touch seems to be about normal over the front of each thigh; it is completely lost over the left buttock, to about four and one-half inches from the anus, and the line of demarcation seems to be sharp. It is lost to about the same extent over the right buttock, but the limitation of this side was not accurately determined, in order to avoid disturbing the patient. The sensation of touch and pain is lost in a narrow zone down the back of each thigh, to, or nearly to, the popliteal space. It seems to be lost or greatly impaired down the back of each thigh, and in the sole of each foot. In the rest of each leg below the knee sensation to touch and pain is greatly impaired, as compared with that of the upper limbs. There is no tenderness over the spine, sacral or coccygeal regions, nor has there been. The paraplegia of the lower limbs occurred within twelve hours, about October 23, 1906. She was probably getting weaker in the lower limbs some time before this. The subjective pain in the left lower limb has been present only about a week, and is about in the same distribution as in the right lower limb, namely, in the outer portion of each thigh. The pain in the right lower limb had been present several months.

A necropsy was not obtained in this case.

In addition to these seven cases, I have observed, as a chance finding at necropsy, in the service of Dr. Dejerine at the Salpêtrière, a lipoma of the filum terminale and a small osteoma of one of the roots of the cauda equina.

The following case is one in which a diagnosis has been very difficult:

CASE VIII.—H. H. P., aged thirty years, was first seen by me in consultation with Dr. A. D. Whiting, February 12, 1903. He had done heavy manual work. He was struck on the outer side of the right knee about eight years ago. He had an extensive synovitis for three months only. In February, 1902, he began to have pain in the right knee. No cause was known for this, and he had not had any injury. He had been working very hard during a strike and over hours. He went out in all kinds of weather and had great exposure, with little rest. Pain came at first in attacks, and the first attack came after he had been out with the snow sweepers. He has never had pain anywhere else than in the right thigh. At first the pain was in the right knee only, and later he thought it extended from the knee up the thigh. He has been treated only for knee trouble. He has pain in the right hip now also, and thinks he has it in the outer and inner sides of the right thigh. It is a steady aching pain, but at times sharp and cutting. When he has the pain all the muscles of the right thigh are sore to pressure, but no tenderness is felt except when he has pain. It is worse at night and when he is in bed. He has been to Hot Springs, Virginia. Atrophy seemed to increase when he was in bed. He had gonorrhœa ten years ago, but never syphilis. An *x*-ray photograph shows nothing in the knee or pelvis, but the acetabulum of the right side may be a little roughened. Dr. Willard says the patient has not bone or joint disease. No malignant history in family, but there is tuberculous history on the mother's side. Very recently he has had a sensation like a tired muscle pain on the outer side of the right leg below the knee. He had been riding horseback before he had pain below the knee. Two other children are in the family. A sister died of typhoid at the age of twenty-three years, in May, 1900. She was fairly well until she had typhoid. An older brother is living and has some bronchial trouble ("fibrinous bronchitis").

Present Condition. February 12, 1903. The patellar reflex is distinctly exaggerated on each side, but more so on the right, where it is much increased. Dr. Whiting says every reflex was normal six weeks ago. Patellar clonus is obtained on the right side, not on the left. Slight indication of ankle clonus on each side. No Babinski is found on either side, and the toes, including the big toes, are flexed. Achilles-jerk is very prompt on each side, and a little exaggerated. Middle of right thigh measures 15¼ inches; left thigh, 16 inches. Middle of right leg measures 12½ inches; left leg, 12¾ inches. The atrophy in the right thigh, inner and outer aspects, is very visible; atrophy of the right leg is also very distinct, but the atrophy of the right thigh is greater than that of the right leg.

Station and gait are nearly normal, even with the eyes closed. He has no Romberg sign and no bladder and no rectal symptoms. Tonicity of lower limbs is about normal. Sensations of touch, pain, and temperature are normal in the lower limbs and equal on the two sides. A slight tendency for the right foot to turn inward is observed. Cremasteric reflex is present on each side, but not very prompt on either side, and more distinct on the left side.

Upper limbs are not atrophied, but he has lost weight generally. Biceps tendon, triceps tendon, and wrist reflexes are very prompt on each side, but biceps tendon reflex is distinctly prompter on the right side. Voluntary power and sensation of touch, pain, and temperature are normal in the upper limbs. Resistance to passive movement is normal in the upper limbs. The hands are not wasted.

Blood examination gives normal findings: hemoglobin, about 87 per cent; over 4,000,000 red blood corpuscles.

Urine, normal; a faint trace of albumin was found only once.

The head is normal. The tongue is protruded straight, not atrophied. Jaw-jerk is not increased. Masseter muscles contract firmly. He has no involvement of muscles of the seventh nerve on either side. The pupils are equal, irides react normally to light, in accommodation and convergence. Movements of the eyeballs are normal. Vision is good.

It is not known how long the atrophy has been present in the right lower limb.

He has no pain on pressure over the spinal column, or on pressure of the head and shoulders downward.

I saw this patient again May 2, 1903. Pain is constant; it has never been better, and at times a little worse than when last seen. The character of the pain has changed; it is sharper, and when he is walking it seems to be confined to the knee. He has no pain in the left lower limb. When he is awakened at night the pain seems more in the hip, and at times in the back. He has no symptoms on the part of the bowels or bladder. His right foot gets cold at times. Pain is still along the front of the thigh, not along the back of the thigh, and not usually below the knee, except occasionally it extends a little below the knee on the front of the leg.

Resistance to passive movement is a little less in the right lower limb. Right thigh (a little below the middle) measures 15 inches; left, 15¼ inches. Right leg measures 13 inches; left, 13 inches. The right lower limb does not appear so much atrophied as it did previously. The right patellar reflex is normal. There is no patellar clonus on either side. Achilles reflex on each side in Babinski position is about normal; if anything, the right is a trifle weaker than the left. Sensations of touch, pain, and temperature in lower limbs are normal, even in front of the right thigh. Gait is normal, except when he has pain. He had some pain just above the pelvis in back during past three weeks; since, he has had passive movement of limb. The pain seems to be confined to the distribution of the right external cutaneous nerve.

The eyes were examined by Dr. Shoemaker. His report is as follows: "The results of my investigations into the ocular condition of the patient are negative. His vision, accommodation, fundus, pupils, ocular movements, muscle balance, and visual fields are normal."

I saw him again November 14, 1903. He had been in California for five months riding horseback and exercising in the open air, and had had Swedish movements, hot sulphur and hot mud baths. The pain has continued as severe as ever, and is in the same place. Sometimes he has pain above the crest of the ilium, and it may extend as high as the lumbar region. He thinks the pain is a little more severe at times. He has never had pain in the back of the thigh nor on the inner side of the thigh. On rare occasions it may extend on the outer side of the right leg half way below the knee. Never has he had any pain in the left lower limb, and never had disturbance of bowels or bladder. He has been *x*-rayed repeatedly, and nothing abnormal has been found. Pain is worse about 2 inches above the patella on the outer side of the thigh. Middle of right thigh measures 16½ inches; of the left thigh, 17 inches. Middle of right leg measures 12½ inches; of left leg, 12½ inches. The right thigh is distinctly atrophied, especially in its inner portion. He weighs now 130. Normal weight is 150. The whole right lower limb is distinctly wasted, but more in the thigh. The gluteal muscles on the right side are also wasted.

The patellar reflexes are prompt, probably more so than normal, but not excessively so. Patellar clonus is not present on either side, and he has no ankle clonus on either side. Achilles-jerk is about normal on each side. Sensations for touch and pain are normal in all parts of the lower limbs. He walks now with a little limp in the right lower limb. No points of tenderness are found in the lower limb. The patellar reflex on the right side may not be quite so prompt as at the former examination.

He was seen by me again April 30, 1904. Since he was last seen Dr. Whiting cut the external cutaneous nerve, December, 1903; he did not suture it or bring the ends together. In February, 1904, Dr. Whiting made an exploratory operation in the lower part of the right thigh, and nothing abnormal was found. General condition has been good, with, at times, mental depression. Pain is unaltered. It still centres about the knee, but extends now more below the knee than into the thigh. He limps, but limping seems to depend upon the pain and varies with the intensity of the pain. The electrical reactions are normal in quality, but diminished quantitatively. The right lower limb, both thigh and leg, is distinctly wasted, and the wasting of the leg is greater than it was at my last examination. The patellar reflex on the right side at times is weak, the leg is thrown forcibly out, but the movement is sluggish. The patellar reflex on the left side is about normal. The Achilles-jerk on the right side, Babinski position, is not quite so prompt as on the left side. The pain is usually on the outer side of the leg, below the knee, seldom on the inner side of the leg, and is of the same character—"sharp, like a toothache or headache—a steady grind, never darts down the limb." Resistance to passive movement is not so good in the right lower limb (flexion and extension of leg or foot) as in the left lower limb. He is analgesic and anesthetic in the outer part of the thigh in the distribution of the external cutaneous nerve, but he has no paresthesia in this area. He has no Babinski sign on either side. Gait is not ataxic, even with the eyes closed. No vesical or rectal disturbance.

At the present time, February, 1907, his condition is about the same as at my last examination. He has been seen by Drs. Osler, Erb, Gowers and other neurologists in this country and in Europe. A small non-malignant tumor, such as the small osteoma I have described above, implicating a few nerve roots, might explain the symptoms in this puzzling case.

I am indebted to Dr. Alfred Reginald Allen for most of the photographs.

MORBID SOMNOLENCE.

By D'Orsay Hecht, M.D.,

ASSISTANT PROFESSOR OF NERVOUS AND MENTAL DISEASES, NORTHWESTERN UNIVERSITY MEDICAL SCHOOL, CHICAGO; ATTENDING NEUROLOGIST TO THE MICHAEL REESE AND ST. ELIZABETH'S HOSPITALS, CHICAGO; CONSULTING NEUROLOGIST TO THE COOK COUNTY INSTITUTIONS FOR THE INSANE, DUNNING, ILLINOIS.

Our present state of knowledge, or lack of it, concerning morbid somnolence, justifies, I believe, this somewhat more than cursory comment of a case seen for the first time during October, 1906:

W. L. J., male, colored, aged forty-eight years, a native of Kentucky, twice married, and a sleeping-car porter by occupation, was kindly referred to the neurological clinic of the Northwestern University by Dr. Gottfried Koehler, whose privilege it had been to observe the patient for a brief period in the medical department.

The essential complaint appearing in the first-taken medical history was that of inability to keep awake. The patient had for a long time prior to his visits to the clinic received various treatments, all aimed at overcoming attacks of sleepiness. From medical premises, a group of symptoms were revealed consisting of very moderate dyspnœa, occasional, severe, but short-lived pains about the heart, insignificant swelling about the feet and ankles, frequent micturition at night, slight periodic headaches, a large appetite, and an inordinate thirst for water. Dr. Koehler reported several analyses of single and twenty-four hour specimens of urine, which showed an average of 0.4 per cent. albumin in 3000 c.c.voided, and the presence of granular, epithelial, and fatty casts in the centrifuged sediment; sugar was absent. The heart was found to be somewhat displaced downward and to the left, the apex beat extending to the nipple line; the second pulmonic sound was not very clear; the second aortic sound was slightly accentuated, but murmurs were not heard. Œdematous swellings at the ankles or along the extremities were not noted, although the patient referred to their occasional presence. These evident signs of renal and cardiac embarrassment, together with the aforementioned subjective symptoms, were taken to indicate the presence of a secondary contracted kidney.

The patient is rather obese, having weighed between two hundred